# Airborne Tracking Sunphotometry

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Atmospheric aerosols (suspensions of airborne particles comprising hazes, smokes, and thin clouds in the troposphere and stratosphere) play important roles in determining regional and global climates, the chemical composition of the atmosphere, and atmospheric transport processes. As knowledge has advanced in each of these fields, so has recognition of the importance of aerosols. National and international bodies have called for increased efforts to measure aerosol properties and effects, as a means of improving predictions of future climate, including greenhouse warming, ozone depletion, and radiation exposure of humans and other organisms.

A fundamental measure of any aerosol is how much it attenuates light beams of various colors (i.e., various wavelengths). This attenuation is usually described in terms of the quantity known as *optical depth*. The dependence of optical depth on light wavelength is the optical-depth spectrum.

The Ames airborne sunphotometers determine the optical-depth spectrum of aerosols and thin clouds. They do this by pointing detectors at the Sun (tracking it) and measuring the (relative) intensity of the solar beam in several spectral channels. The tracking head of each instrument mounts external to the aircraft cabin, thereby increasing data-taking opportunities relative to in-cabin sunphotometers and avoiding data contamination by cabin-window effects. Each channel consists of a baffled entrance tube, interference filter, photodiode detector, and integral preamplifier. The filter/detector/preamp sets are temperature-controlled to avoid thermally induced calibration changes. Each instrument includes an entrance-window defogging system to prevent condensation (a problem otherwise common in aircraft descents). Solar tracking is achieved by azimuth and elevation motors driven by differential Sun sensors. In general, Sun tracking is achieved continuously, independent of aircraft pitch, roll, and yaw, provided that change rates in those axes do not exceed about 8 degrees per second and that the Sun is above the aircraft horizon and is unblocked by clouds or aircraft obstructions (e.g., tail, antennas). Data are digitized and recorded by an onboard data-acquisition and control system. Real-time data processing and color display are routinely provided. The science data set includes the detector signals, derived optical depths, detector temperature, Sun tracker azimuth and elevation angles, tracking errors, and time. Each instrument must maintain its radiometric calibration (including window and filter transmittance, as well as detector responsivity and electronic gain) to within 1% in each spectral channel for periods of several months to a year.

The 6-channel Ames Airborne Tracking Sunphotometer made its first flights on the NASA CV-990 aircraft in 1985. Since then, it has flown on a wide range of NASA and other aircraft. Its measurements have been used to validate NASA satellite data bases and to discover new information on urban and marine hazes, desert dust, biomass- and fuel-burning smokes, cirrus clouds, and volcanic aerosols. Most recently, it measured U.S. pollution haze from a C-131 over the Atlantic in the Tropospheric Aerosol Radiative Forcing Observational Experiment (TARFOX, July 1996), and European pollution aerosols, African dusts, and water vapor from a ship in the Second Aerosol Characterization Experiment (ACE-2, June–July 1997).

The 14-channel Ames Airborne Tracking Sunphotometer was developed under the NASA Environmental Research Aircraft and Sensor Technology Program. It made its first science flights on the Pelican (modified Cessna) aircraft of the Center for Interdisciplinary Remotely Piloted Aircraft Studies during TARFOX in July 1996. Mountain calibrations were conducted at the Zugspitze in Germany as part of the Pre-ACE-2 Radiometer Intercalibration in October 1996. Airborne calibrations and further test and science flights were made in California and over coastal waters in conjunction with Navy flights of the Pelican in November 1996. After calibration at Mauna Loa Observatory (Hawaii) in May 1997, it again flew on the Pelican in ACE-2 (June–July 1997), measuring European and African aerosols, water vapor, and ozone. The analysis of measurements will help in understanding the effect of man-made and natural hazes on Earth's climate.

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